

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2015 examinations

Subject ST9 – Enterprise Risk Management

Purpose of Examiners' Reports

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

F Layton
Chairman of the Board of Examiners

July 2015

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Candidates' answers are made up of a series of points. For example, a point can be stating a valid type of risk, describing the type of risk or (part of) a calculation. Some points are more fundamental to the correct answer but, in the main, candidates earn one-half mark per correct point up to the limit of marks available for the question.

Comments on the April 2015 paper

The paper was made up of one large question and two shorter questions. Question 1 was a case study with two main themes being parameterising a capital model and the usefulness of a developed ERM when managing a crisis. Question 2 focused on identifying and analysing emerging risks and question 3 concentrated on problems which often arise when hedging. The paper was quite practical in its content and overall contains the targeted balance of bookwork and application and the range of content needed to reasonably cover the syllabus.

As is common practice, the large majority of the questions were:

1. based heavily on bookwork;
2. based on simplified case studies or;
3. loosely based on actual and often relatively recent events.

The examiners seek to test the candidate's knowledge of the syllabus. The core reading is an important source for framing questions but not the only source. For this reason, candidates are encouraged to read the financial press and to consider how current news items can be applied to the issues and concepts contained in the core reading.

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

- 1** (i) There are a number of points to note in considering the available data, the empirical distribution, the fitted loss curve and, in particular, the 99.5th percentile stress:
- Firstly, data is only available for a relatively small number of years, which is unlikely to be statistically significant.
 - The period covered may or may not include periods of stress consistent with those seen once every 200 years.
 - The graph showing the empirical distribution of equity price index movements includes thousands of data points, suggesting that overlapping periods of exposure have been considered.
 - While using a shorter period usually serves to increase the relevance of the data it is not clear that the past period here provides a good guide to the future, given the changes to Solvania's aluminium industry.
 - Based on the analysis provided, it is not clear whether any adjustments have been made to reflect this.
 - The empirical equity distribution appears to have a significantly positive skew which, in a Monte Carlo simulation, will bias results positively.
 - The t -distribution is a symmetric distribution so fitting it may not therefore be appropriate.
 - Alternatively, the empirical distribution may possibly be bimodal or, perhaps more likely, involve a regime shift.
 - Based on the table showing selected percentiles for the empirical and fitted t -distribution, the fit across the range lying between the 5th and the 95th percentile does not look unreasonable for the percentiles quoted recognising that a perfect match is not possible nor desirable due to over-fitting.
 - However, there seems to be some bias in the 5th to 20th percentile range, with the fitted distribution being consistently over-stated.
 - And at the extremes of the loss curve the fit is even less optimal.
 - The fitted t -distribution is producing more extreme results at the tails i.e. higher highs and lower lows.
 - The 0.5th percentile for the empirical distribution is 83% while for the fitted t -distribution it is 93%. In a Monte Carlo simulation (using the fitted t -distribution) this will result in more extreme positive equity price increases than have been observed.
 - The fit at the 99.5th percentile is worse still, with the percentile for the empirical distribution being –52% while for the fitted t -distribution it is –74%. In a Monte Carlo simulation (using the fitted t -distribution) this will result in more extreme negative equity price decreases than have been observed.
 - The fitted 99.5th percentile stress of –74% is greater than any of the observations.
 - It is also greater than any of the multi-year stresses detailed in the table showing example crises and their impact on the Solvanian stock market.
 - That said, given the short period of data collection (which may well not include a 1 in 200 year event), extrapolation using a t -distribution may be

expected to yield a more onerous stress and this could therefore be acceptable.

- The fit might also be acceptable if the combined worst 1 in 200 scenario includes an equity stress around (or below) the 95th percentile, and hence the fit of the loss curve around (or below) the 95th percentile is of paramount importance.
- It should also be noted that the proposed equity stress is based only on movements in the equity price index and so does not include any stress in respect of equity dividend income.
- The equity price index components also might not be consistent with the actual portfolio holdings.

The question was handled well by most. Many candidates either answered the question qualitatively or quantitatively. The best answers took both approaches. Additional valid points include:

- *t-distribution has fatter tails than a normal one and so might be better than a normal distribution.*
- *Variation in volatility over time and/or regime shift may have occurred.*

(ii)

- Adjust the data to remove the dependencies and overlap, or allow for the dependent nature in the fitting analysis.
- Perform a high level review of data over a longer period of historic time in order to gain more understanding of potential 1 in 200 year events.
- Investigate what other countries in similar circumstances have experienced.
- Consider whether an adjustment to the loss curve and 99.5th percentile stress is required in order to reflect the trends and changes in the aluminium industry.
- Investigate the stress level at which the equity stress is actually modelled.
- If it exceeds 95%, perform further analysis and review the model fit.
- Consider use of a skewed, bimodal or hybrid distribution for the fitting.
- Ensure that the stress is being used for prices only, not for total return including equity income. (Or adjust the stress to allow for equity income stress also.)
- Estimate the basis risk between the equity price index and SARS's own portfolio and adjust the equity price index data accordingly.

Most candidates expanded on their part (i) analysis. Other valid points included:

- *Look at any industry shared practice and/or what other companies are doing*
- *Use expert input, particularly regarding the future of the aluminium industry*
- *Use an Extreme Value Theory approach as only really interested in the tail*
- *Use scenario testing.*

(iii)

- Examining the lapse data does not reveal any evidence of policyholder behaviour being strongly correlated to the performance of the Solvianian stock market in that year.
- That said, the lapses do appear to increase over time.

- This could perhaps reflect the lack of attractiveness of the Solvian stock market given the structural changes to the aluminium markets.
- SARS has rightly reflected the above increase trend in its base lapse assumptions.
- The mean deviation in actual experience from SARS' expected experience is zero.
- However, this averages across some large deviations, suggesting that it is difficult to estimate the lapse rate in any one year.
- There is a particularly high lapse rate in 2003, which appears to be an outlier within this period of observation.
- This may have been due to the Bowser crisis in 2003, which coincided with the spike in lapse rates.
- Or a large increase in lapses in the year may have resulted from one-off changes in legislation or taxation.
- If this is the case then the repeatability of such events needs to be considered when deciding whether to remove this data point.
- The highest experienced lapse rate over the period from 1998 to 2014 (i.e. the figure that has been selected) is also the empirical 99.5th percentile stress.
- But with the limited data points available this is probably not sufficiently extreme as we may not have observed a 1 in 200 stress event over such a short period.
- Extrapolating using a normal distribution with mean 0.0% and standard deviation 1.5% (based on these observations) would yield a 99.5th percentile stress of 3.9%.
- However, this distribution does not have fat tails and it is based only on the standard deviation experienced over this relatively short period.
- Because the lapse stress is based on the difference between actual and expected lapses, it needs to take into account how actively the expected lapse rate is changed by the company.
- The data provided suggests that it is periodically reviewed and updated but it is not actively changed every year, i.e. changes are smoothed in and only made in 1.0% steps.
- It may be appropriate to consider using a higher lapse stress during years when the assumption has not been adjusted for some while, relative to years when it has recently been revised.
- As the correlation between lapse rates and equity prices is low some diversification benefits can be assumed.
- That is when equity prices are stressed at the 99.5th percentile it is not appropriate to assume a lapse rate at the 99.5th percentile.

The question was handled poorly by most. Many candidates made three or four of the above points but no more.

(iv) In practice we would expect:

The volatility of spreads should be expected to reduce with reduced outstanding term to maturity since there is less time for adverse events to impact the payment of the coupons and redemption amounts.

However, the 99.5th percentile for 1 to 2 year A* rated corporate bonds is higher than the 99.5th percentile for 3 to 5 year A* rated corporate bonds, which is unintuitive.

The volatility of spreads for the higher grade rating categories should be lower than for lower grade rating categories since the credit rating should reflect the relative security of each bond issue following the rating agency's review of the issuer provided the credit ratings are sufficiently up-to-date and are set using a robust methodology.

However, the 99.5th percentile for 3 to 5 year A rated corporate bonds is higher than the 99.5th percentile for 3 to 5 year B** rated corporate bonds, which is unintuitive.

Most candidates scored near full marks.

- (v) If there is sufficient data available the bonds could be analysed at a greater level of granularity: For example, by grouping the corporate bonds into industry sectors and analysing each separately or analysing them by year rather than over grouped years.

It could use (or blend in) data from other countries which have more major bond markets particularly if the credit markets have a global investor base.

The analysis should be adjusted to remove spread widening that has occurred due to rating downgrades and defaults over the course of the year, if this has been allowed for elsewhere (to avoid double-counting). [Or alternatively, spread widening due to downgrades and defaults should be split out separately in the analysis.]

The spread widening and risk associated with downgrades and defaults should also be captured for government debt.

Corrections should be made to the non-intuitive results mentioned in the previous part.

However, further analysis is required in order to determine which particular figure should be adjusted in each case, and it may be that more than one figure has to be amended.

The question was handled reasonably well by most. Many candidates did not make a sufficient number of valid points. Other valid points included that liquidity and structural terms also contribute to spread.

- (vi)
- Decide on the scale of calculation e.g. daily, weekly, monthly or annual data.

- Decide on the timeframe from which the data should be taken balancing between volume and relevance of data.
- The data should represent the gross redemption yields for risk-free bonds of a range of maturities, with the yields for each maturity forming a distinct series.
- For each maturity series, calculate the average of these yields over the period for which the data are taken.
- Determine the deviations from this average.
- Identify a number of principal components that explain a sufficiently high proportion of these past deviations and set them e.g. using an iterative process.
- Project this number of independent, normal random variables with variances equal to the relevant eigenvalues.
- Obtain the projected deviations from the expected yields for each maturity by weighting these series by the appropriate elements of the relevant eigenvectors.
- Derive an expected yield from current risk-free bond prices.
- Add these expected yields to the simulated yield deviations to give a range of projections of future yield curves.
- The analysis can be done using the yields directly or using their natural logarithms.

The question was handled poorly by most. Many candidates made two or three of the above points but no more. The question was a bookwork question.

(vii)

- It is likely that three principal components will be sufficient.
- One for changes that cause the whole yield curve to rise or fall.
- One for those that cause the slope of the yield curve to change.
- One for those that cause the yield curve to bend around a particular term.
- It is expected that around 95% of the variability can be captured using only these three principal components.

The question was handled poorly by most. As for part (vi) above the question was essentially a bookwork question but was not well known to many.

- (viii) Assume that Solvania and Insolvania both use their own currencies, the \$ and the # respectively.

Simplistically, if both the business written within Solvania and the business written within Insolvania have a 200% solvency ratio, then, all else being equal, a change in the exchange rate between the \$ and the # will not change SARS's solvency ratio, which will remain at 200%.

However, if the business written within Solvania has a 190% solvency ratio (say) whilst that written in Insolvania has a 220% solvency ratio (say) so that SARS has a 200% solvency ratio overall, then if the # weakens against the \$ then the weight given to the surplus in respect of the business written within

Insolvania decreases whilst the weight given to the surplus in respect of the business written within Solvania increases.

Therefore, without currency hedging SARS's solvency ratio would decrease.

Forward exchange contracts could be used to short or decrease exposure to the # and long or increase exposure to the \$, thus immunising SARS from currency movements.

The reverse is also true. Assume that the business written within Solvania has a 210% (say) solvency ratio whilst that written in Insolvania has a 180% solvency ratio (say) so that SARS has a 200% solvency ratio overall. If the \$ weakens against the # then the weight given to the surplus in respect of the business written within Solvania decreases whilst the weight given to the surplus in respect of the business written within Insolvania increases.

Therefore, without currency hedging SARS's solvency ratio would decrease.

Forward exchange contracts could be used to long or increase exposure to the # and short or decrease exposure to the \$ immunising SARS from currency movements.

The question was handled relatively poorly by most. Many candidates made three or four of the above points but no more. The question was allocated four marks and so would normally require eight valid points for full marks.

- (ix) The approach ignores interdependencies between risks.

In particular, if the solvency ratio for business written in Insolvania is lower than the solvency ratio for business written in Solvania, then the simplified example above illustrates that SARS should decrease its exposure to the \$ whilst increasing its exposure to the #. Given the likelihood of the Insolvania government defaulting on sovereign debt and the pressure on the #, this unintended consequence may not be a preferable course of action for the Board of SARS to execute.

The Board is unlikely to want to increase exposure to a currency that is likely to decrease further.

The question was handled reasonably well by most. Many candidates did not make a sufficient number of valid points. Other valid points included:

- *The approach may be costly, particularly as the government is just about to default.*
- *Counterparty risk could be high, particularly as the government is just about to default.*
- *Margin management / related liquidity issues.*
- *Gives away upside.*

(x) Alternative objectives that SARS could employ include:

- Hedging the # denominated surplus or surplus over and above a risk appetite threshold.
- Hedging the expected near term cashflows, such as internal dividends, arising from the business written within Insolvania.

The question was handled well by most. Other valid points included:

- *Allow a % change either way on the solvency ratio with a given probability (i.e. not just that it has to stay the same).*
- *Target the level of capital held against currency risk.*

(xi) Capital should still be held in respect of SARS' currency risk.

This is because the currency hedging is assessed on a standalone basis and ignores interdependences with other risks.

There may also be currency risk exposures within the business written in Solvania or Insolvania.

For example due to writing business in countries other than Solvania or Insolvania.

Or due to holding assets to back the immediate annuities (for example) which are denominated in a different currency.

Most candidates scored full marks. Other valid points included:

- *The hedging introduces counterparty risk which should require capital.*
- *The regulator could require capital to be held at a minimum level against currency risk and/or against a currency hedge.*

(xii) By its nature a crisis will impact SARS in a number of different ways that cannot be fully known in advance.

Also by its nature a crisis happens quickly. It is sub-optimal to simply react to it as it unfolds.

It could also trigger a number of related contagion events that need to be identified and managed.

ERM:

- Identifies and registers risks
- Quantifies the potential cost of risks given a range of different scenarios
- Is a holistic approach to risk management and so ERM estimates the potential relationships between different risk types and between the same risk types in different operational areas given a range of different scenarios
- Sets limits to SARS's appetite or tolerance for certain risks

- Contains a reporting framework including the timing and type of reporting and the personnel involved.

All of these attributes of ERM are needed to develop a comprehensive crisis management plan.

ERM will help SARS to enable the board and management to:

Before the crisis

- Prepare for the crisis by creating a plan and having the plan approved by the board and management
- Discuss and action measures to avoid, mitigate, and/or transfer risks e.g. sell or hedge any exposure to Insolvania's sovereign debt
- Implement risk mitigation strategies whilst they are relatively cheaper prior to the crisis.

During the crisis

- Manage the crisis with increased operational effectiveness
- Better risk reporting
- Improved business performance
- Minimise the financial and operational impact of the crisis
- Potentially profit from the crisis
- Reorganise the company
- Market confidence: protect SARS's relationships with its external stakeholders including regulators, rating agencies and shareholders.

After the crisis

- Crisis analysis including lessons learned
- Contagion now and in the future
- Market confidence.

The question was handled well by most. Other valid points included:

- *ERM identifies the most appropriate mitigation technique, if any, for each risk, and*
- *Sets an effective risk culture, and*
- *Allows an appropriate allocation of capital.*
- *Before a crisis, ERM identifies it as a potential (emerging) risk, and*
- *Allocates ownership of that risk to someone, who can then co-ordinate the responses, and*
- *Puts early warning indicators in place.*
- *During a crisis, ERM enables better monitoring processes.*

- (xiii) SARS is exposed to the following risks that could possibly be covered under the insurance:

Lapse risk from existing insureds on unit-linked business

The default could result in a recession or depression which in turn would be expected to increase lapse rates e.g. due to unemployment or reduced affluence making it more difficult for policyholders to continue to pay premiums or due to policyholders panic selling when the value of the policies fall.

For unit-linked business, higher lapses will mean lower profits as it reduces the flow to SARS of charges in excess of expenses.

However, it could be very difficult to separate out lapse losses caused by the default from the rest.

SARS would have to do a trend analysis on the lapse experience.

Further, the lapses would have to occur within the coverage period of the business interruption insurance policy – which is likely to be relatively short.

New business volume risk

New business placed by third party intermediaries (e.g. brokers and tied agents) could fall as some of the intermediaries could stop trading as a result of the changes in the economy post the default.

Demand from potential new customers may fall for the same economic reasons as mentioned above in respect of higher lapses.

Lower than expected new business will mean lower profits for SARS.

It could be reasonable to assume that they would have continued to place business at the pre-default levels for the purpose of calculating SARS's lost profits.

The calculation would be made more difficult as SARS's profit on life insurance contracts is made over a long period of time.

Operational risk

Outsourcers (if covered) and other suppliers may stop trading as a result of the changes in the economy.

A new outsourcing or supplier arrangement may be more expensive.

Taking any previously outsourced administration functions back in-house could be costly.

These additional costs should be relatively straightforward to determine although detailed expenses analyses may be needed if brought in-house.

There may be additional legal expenses.

The default could lead the government to impose additional costs and taxes on the subsidiary.

These could be covered by the insurance to the extent that they could be attributed to customers and/or suppliers.

The question was handled well by some and poorly by others. Other valid points included:

- *Increased withdrawals could generate liquidity issues and hence reduced profit if assets have to be liquidated at sub-optimal prices.*
- *Suppliers may put up their prices materially.*

- *There may be an increase in customer fraud, e.g. relatives continuing to claim on an annuity after the death of annuitant. This may be difficult to quantify (unless there have been past precedents).*

2 (i)

- The information provided suggests that the risk management culture is likely to be weak.
- The Chairman should drive risk management culture “from the top” within the trustee group in the same way that the Board should drive culture within an organisation.
- Although the leadership appears to be consultative as the Chairman listens to the viewpoints of others in practice the viewpoints appear to be disregarded if they do not coincide with his.
- Similarly, although the other trustees appear to be participating in decision-making in practice they do not have any influence.
- It is likely that in time the other trustees will therefore stop bothering to express opinions which differ from those of the Chairman, if this has not already happened.
- Therefore risk management will no longer be properly debated or discussed.
- It is unlikely that the culture is one of openness.
- It is not clear whether there is a blame culture, but the other trustees might feel that they will be criticised if they do not have the same view as the Chairman.
- If the Chairman rarely accepts any decision other than his, there is limited opportunity to learn from new ideas.
- Knowledge sharing may generally be limited.
- It may become the case that the other trustees start to communicate more with each other, excluding the Chairman.
- The other trustees may become increasingly resentful of the situation and this can also reduce the sharing of information and views.
- Reporting of information which is likely to be unpopular with the Chairman may simply not happen.
- There is a high risk of bias due to the level of control exerted by one individual.
- He might wish to cover up situations that would reflect badly on him, given that he seems to enjoy status.
- It is unlikely that best practice risk management can be followed if it is based on the decisions made by one individual.
- It is not clear whether the Chairman makes good decisions in relation to general risk management but the comment on emerging risks suggests that he does not.
- The purpose of the trustees is to ensure ongoing security of the pension scheme.
- Ignoring emerging risks completely appears to be highly dangerous and short-sighted.

- The point about being difficult to understand suggests that the Chairman may not want to bother with anything that he personally does not understand. This is a dangerous attitude.

The question was handled well by most.

(ii)

- A holistic view is required for emerging risk identification and analysis, considering all possible impacts of the new risk before this is reduced to the more structured analysis approach typically taken for known risks within a risk framework.
- The key identification tool is horizon scanning.
- i.e. the systematic search for potential developments over the longer term with the emphasis on those changes that are at the edges of current thinking.
- This requires input from experts who understand the underlying drivers and the technological/scientific/economic/socioeconomic aspects.
- It is most likely that expertise will need to come from external sources.
- This includes academic journals and websites relevant to the specific area.
- Since by definition it is unlikely that there will be a definitive study on any particular aspect each needs to be assessed from different angles and sources.
- Risk management decisions then need to be weighted according to the credibility and reliability of the underlying “evidence”.
- Continual monitoring of developments in relevant research will be important in order to refresh these decisions.
- The more alarmist media reports can be useful in alerting the organisation to potential areas for further investigation.
- However, they should not in themselves be used as a basis for decision-making.
- Additional analysis should be performed where the potential financial impact rests on the likely future legal approaches to such emerging factors.
- An analysis of trends is important.
- Also need to monitor regulatory activity and lobbying activity in that sector.
- When analysing trends, it is important to keep dependencies in mind and changes in dependencies.

The question was handled well by most.

(iii) *Assets*

Resource constraints will steadily increase as the earth's finite natural resources are used by the increasing population.

This could lead to an increase in energy prices and commodity prices over the duration of the scheme's liabilities (say the next 30 years).

Increases in the cost of energy and commodities may result in lower economic growth.

This is likely to lead to an increased indebtedness and hence an increase in bankruptcies and defaults.

Lower economic growth could lead to reduced international coordination, which is ultimately self-defeating leading to even lower economic growth.

This could take the form of trade barriers or selective defaults on overseas holdings of government debt.

Worse still, international security may be reduced as governments scramble for limited resources.

This may lead to differential investment returns where governments direct investment into alternative sectors to make their economies more stable.

The cost of that stability may be so high as to elevate debt levels beyond their already heightened levels.

This may lead to an increase in bankruptcy of governments.

Increased social tension may arise as inequality and hardships are heightened resulting in challenges to law and order.

Property damage could be expected to increase as a result of vandalism or riots.

This is likely to lead to a lower value being placed on property assets held by the pension scheme.

Further still, increases in the prices of energy and commodities may lead to decreases in the prices of other assets such as properties, as the higher prices previously demanded can no longer be afforded. This is likely to lead to a lower value being placed on property assets.

The above are all likely to reduce the value of the scheme's assets.

Liabilities

Increases in input costs will lead to higher price inflation.

Higher inflation will, usually, increase the value of the schemes' liabilities.

To ensure energy security governments may opt to utilise fossil fuels, accelerating climate change.

The more extreme and, on average, warmer temperatures, could lead to a reduction in the food available to feed an increasing population.

This could lead to higher food prices and poorer diets, leading to reductions in life expectancy.

Lower access to affordable medical care, brought about by the increased costs of that care and lower disposable incomes, may lead to reductions in life expectancy.

Reductions in the life expectancy of the scheme's members will reduce the value of its liabilities.

Deficit

Any reduction in assets or increase in liabilities will increase the deficit of the pension scheme.

Any increase in assets or reduction in liabilities will reduce the deficit of the pension scheme.

More generally the diminishing natural resources could negatively impact the company's ability to meet the company contributions in the future.

Ongoing deficit problems could force change on the scheme e.g. closure to new entrants, transfer outs, changes to future benefits etc.

The question was handled well by most. Other valid points included:

Assets

- *Taxes may be increased.*
- *Increased volatility of asset values.*
- *Political uncertainty / rapid change of governments.*
- *Some investments may increase in value (e.g. renewable energy companies).*

Liabilities

- *Members may want to cash in their pensions early.*
- *Increased interest rates would reduce the value of the liabilities.*

(iv)

- In the short term, possibly through investment in energy companies' debt and equity.
- Similarly commodity companies.
- Investment in only the debt of the scheme's domicile.
- Or by diversifying the holdings away from any one government.
- Investment in security companies' debt and equity.
- Investing in assets that are expected to provide a real return, e.g. inflation-linked bonds.
- Heightened monitoring of inflation rates, political activities and so on, so that the pension scheme can take protective measures sooner rather than later.

The question was handled well by most. Other valid points included:

- *Get the employer to increase their contributions.*
- *Restrict withdrawals.*
- *Wind it up / do a buy-out / reduce or cap benefits etc...*

- 3** (i) If the maturity date of each equity release mortgage was known, the insurer could work out the required annual house price growth rate for each mortgage such that the guarantee exactly bites.

This would be done by rolling up the loan at 6% per annum to that date and then determining the level annual house price growth rate needed in order for the projected value of the house to equal the accumulated loan at the maturity date.

However, the situation is more complicated because the mortgages are repaid on the sale of the property following the death of the homeowner(s), which is an uncertain date.

The length of time required to sell the property following death is also uncertain.

The insurer therefore needs to establish a probability weighted house price growth rate for each mortgage in each projection year using best estimate mortality rates.

From this, a set of inflation-based strikes would be determined for each outstanding term.

This would be done for a period of up to (say) 50 years.

The strikes would be rounded to the nearest 0.5% say.

For each year, the insurer would derive a probability weighted notional required at each house price growth rate strike.

The notional would be based on the relevant house values.

A hedge can then be constructed for each mortgage through using a series of floors on the country's HPI with the notional and strikes as assessed above.

The above approach is repeated for each mortgage and the results aggregated.

"Nearest best" floors may be necessary if the full range of required strikes and terms is not available.

The question was handled relatively poorly by most. Many candidates did not understand how a floor would work and so discussed swaps. Other valid points included that the hedge could be structured as a bond.

(ii)

- There is basis risk i.e. the house value may not increase in line with HPI.
- This may occur because the money raised from the loan is used to redecorate the home, leading to outperformance or because as the homeowners age over time their property becomes dilapidated as they become unable to maintain the property, leading to underperformance.
- It may be due to the houses covered being atypical of those in the HPI e.g. due to a concentration in a particular geographical area or a higher weighting than in the HPI of the type of property typically owned by those in retirement such as smaller houses or bungalows.
- A large number of distinct floors is likely to be required, which could incur high transaction costs and greater derivative management expense.
- The bank may not be willing to provide the wide number of different floors needed across all strikes and terms.
- The hedge, as constructed above, would be based on averages and the timing of hedge cashflows is unlikely to coincide with the cashflows on the equity release mortgages.
- This may lead to liquidity concerns or risk.
- The hedge would expose Easy Retirement to credit risk in respect of the bank although this could be addressed by requiring collateral to be deposited.

The question was handled well by most. Many candidates made a large number of the above points. Other valid points included that the hedge might not be allowed for capital reduction and particularly if the hedge is not perfect.

- (iii) The recommendation is that the insurer should not use floors on the RPI to hedge the guarantee.

There is too much basis risk.

Underlying trend structures in the data should be removed before correlating the residual random errors. The bank does not appear to have done this for its correlation calculations. The remaining comments are based on the bank's correlation coefficients.

The bank appears to have chosen the correlation measured over a 15 year period to best suit its argument, as this gives the highest correlation. The correlation as measured over shorter and longer time frames is not as high.

The correlation between the indices over shorter periods is much lower than the correlation measured over longer periods. This is intuitive as retail prices and house prices may move differently in individual years and over short periods. There will also be greater statistical variation over shorter periods. Using the RPI floor will therefore be much less likely to be a good hedge over shorter periods.

While the correlation measured over longer periods is very high – over 80% – this simply indicates that an upwards movement in one index is very likely to occur at the same time as an upwards movement in the other. It says nothing about the quantum of the movement.

As we can see from the first graph, the cumulative increase in the RPI is far lower than that for the HPI. So hedges related to the RPI may not provide a good hedge where house prices diverge significantly from retail prices.

It may be possible to leverage up the increases in the RPI based on the historical difference, but there is no guarantee that the quantum of the difference going forward will match that over the period from 1969 to 2012.

The question was handled well by most. Many candidates made a large number of the above points. Other valid points included:

- *Correlation over shorter periods would be more important for equity release mortgages sold to the very elderly.*
- *Although the correlation is high for most durations, the correlation is not perfect.*

(iv)

- Check the information provided by the bank.
- Perform analysis to understand whether historical data prior to 1969 is consistent with that analysed by the bank.
- Similarly for more recent data, after 2012.
- Investigate whether there are specific events that could lead to a divergence between the two indices.
- For example, the country's central bank may decide to target both house prices and retail prices or outsourcing to developing countries may depress retail prices due to the availability of cheaper labour.
- Estimate the basis risk between the indices.
- Investigate the possible use of another index, i.e. other than the RPI.

The question was handled well by most. Many candidates scored full marks.

END OF EXAMINERS' REPORT